RENEWABLE ENERGY SEAWATER DESALINATION
WATER-ENERGY NEXUS AT THE HEART OF THE UNITED ARAB EMIRATES’ HERITAGE AND FUTURE
Global water consumption doubles every twenty years, more than twice the rate of population growth. This is one of the world’s most pressing issues, both economically and socially, and is especially critical in arid regions.

Listed by the UN as one most water-scarce countries due to its arid climate, water scarcity has been a primary concern for the United Arab Emirates since the nation’s inception.

With a rapidly growing population and economy, the United Arab Emirates has emerged as a recognised, responsible leader in the water sector taking on the challenges of water conservation, management, and security.

The United Arab Emirates has put sustainability at the heart of its growth strategy and is actively promoting the adoption and expansion of the most advanced and innovative technologies to reduce water consumption, costs and waste using minimal resources and limiting environmental damage.

THE UNITED ARAB EMIRATES HAS A HYPER ARID CLIMATE
- less than 100 mm/year rainfall
- groundwater recharge rate of less than 4% of the annual water used
- no reliable, perennial surface water resources

30% GROWTH
Water demand in the United Arab Emirates is projected to grow 30% by 2030

Masdar’s Renewable Energy Seawater Desalination Programme
DESALINATION IN THE UNITED ARAB EMIRATES

Desalination is a critical component of the United Arab Emirates’ sustainable growth
Desalination has been the major source of potable water in arid regions for years, and a critical component of sustaining life and economic growth in the Gulf region.

The overall installed capacity in this region amounts to about 62% of the world’s desalinated water capacity, and the United Arab Emirates stands as the second largest producer following the Kingdom of Saudi Arabia.

In the past, the desalination market in the Middle East was largely driven by robustness rather than efficiency, and water production was realised through costly and energy-intensive processes.

Today, the situation is quite different as the United Arab Emirates is committed to further advancing industrial-scale, sustainable desalination technologies capable of meeting the region’s future demand for fresh drinking water. Recognising the link among energy, water, and food, the United Arab Emirates is investing heavily in cutting-edge technologies to improve the efficiency and reduce the environmental impact of the desalination process.

Abu Dhabi and Masdar, the renewable energy company based in the United Arab Emirates’ capital, have made a commitment to decrease the use of traditional energy sources for desalination and in turn power desalination with the region’s abundant renewable resources, such as solar or geothermal. This solution will improve water security, reduce the environmental impact of desalination, and reduce the cost of potable water.

By bridging the gap between research and development and commercialisation, the United Arab Emirates is providing an opportunity for scale-up of technologies that address water access, while also reaping economic, social and environmental benefits.

In the United Arab Emirates, seawater desalination requires 10 times more energy than surface fresh water production, and its cost is projected to increase by 300%
THE UNITED ARAB EMIRATES’ RENEWABLE ENERGY SEAWATER DESALINATION PROGRAMME

Transforming the desalination industry into a more sustainable model
Masdar launched the Renewable Energy Desalination Programme in January 2013 following a mandate from Abu Dhabi’s leadership.

This forward-thinking mandate directed Masdar to develop and demonstrate advanced and innovative technologies in desalination to both ensure water security and reduce energy consumption in the sector in order to meet the United Arab Emirates’ energy reduction targets.

The goal of this programme is to identify industrial-scale and commercially viable desalination technologies that will address sustainable access to water both in the arid region and globally.

Specifying sustainability and energy efficiency as the primary focus represents a novel approach to an industry-wide challenge and is designed to create the right synergies between the academic and research worlds, industry and public institutions.

The programme consists of two stages:

**STAGE 1**

Demonstrate energy-efficient desalination systems at a small scale. The programme will include and operate four pilot plants, which will be located in Ghantoot, Abu Dhabi. The pilot plants are expected to be operated on a continuous basis for at least 18 months to demonstrate the reliable performance of the developed technologies.

**STAGE 2**
(2018 - 2020): IMPLEMENTATION

Implementation of the developed energy-efficient desalination technologies on a large-scale in the United Arab Emirates and the wider MENA region through seawater desalination plants completely powered by renewable energy. Operate a commercial scale facility by 2020.

Key benefits for the United Arab Emirates:
- Increased energy efficiency
- Diversification of energy supply
- Cost reduction of desalinated water
- Reduced environmental impact
DESALINATION TECHNOLOGIES
Bridging the gap between research & development and commercialisation
The Renewable Energy Seawater Desalination Programme foresees the demonstration of two different technologies:

**TYPE ONE**

**Advanced technologies** - defined as technologies that are based on commercially proven systems - are expected to have the potential to lower the specific energy consumption to reach the following target values:

- Reverse osmosis plants: less than 3.6 kWh/m$^3$ of electric energy* (see footnote)
- Thermal desalination plants: less than 1.0 kWh/m$^3$ of electric energy and a specific thermal energy consumption varying in accordance to the temperature of the inlet energy stream as per Figure 1.

**TYPE TWO**

**Innovative desalination technologies** - defined as technologies that are based on novel concepts for seawater desalination - have the potential to lower the specific energy consumption to reach the following target values:

- Membrane based processes: less than 3.1 kWh/m$^3$ of electric energy* (see footnote)
- Thermal desalination processes: less than 1.0 kWh/m$^3$ of electric energy and a specific thermal energy consumption varying in accordance to the temperature of the inlet energy stream as per Figure 2.

*The target values are based on seawater with a concentration of total dissolved solids of 42,000 mg/L and a temperature of 30°C.

Concurrently with the pilot projects in Ghantoot, Masdar Institute of Science and Technology is collaborating to support the programme through a series of research projects including:

- A study and evaluation of membrane scaling and fouling in membrane distillation modules to mitigate problems and develop appropriate cleaning protocols
- Developing an optimised design of a full-scale solar energy powered seawater reverse osmosis (SWRO) plant using the most practical and economical PV and solar thermal energy technologies
- Capacitive de-ionization for treatment of permeates from the first-pass Reverse Osmosis to demonstrate the cost and energy savings potential in SWRO
- The development and testing of high-temperature forward osmosis membranes and manufacturing techniques.
FORGING PARTNERSHIPS FOR SUSTAINABLE ADVANTAGE
The first stage of the programme concentrates on demonstrating energy-efficient desalination systems on a small scale.

The site of a decommissioned desalination plant in Ghantoot was selected as project site due to accessibility to deep seawater, availability of electricity and natural gas.

The four desalination pilot plants will be built on the same site, and auxiliary facilities will be shared among the four plants as shown in Figure 3.

The electricity consumed by the pilot plants will be supplied by the national grid. The heat for the desalination pilot plants will be provided by a central boiler unit, fired by natural gas and solar thermal collectors.

Each desalination plant will be designed, engineered, constructed and operated by a selected technology provider. In February 2013, Masdar invited 180 different companies and organisations in the water desalination industry to participate in this unique programme.

Masdar partnered with four key players of the desalination industry:
- Abengoa - Spain
- Suez Environnement/Degremont - France
- Veolia/STEDM - France
- Trevi Systems - USA

The technologies used in these programmes have passed research, lab testing, modelling and prototyping. However, the technologies have not been commercialised nor used on a utility scale anywhere else in the world.

The second stage of the programme will concentrate on one or more large-scale seawater desalination plants using the highly energy-efficient desalination technologies developed in stage one.

The desalination plants will be powered by renewable energy, mainly PV and CSP.
Pioneering Next Generation Desalination

1/3 UAE greenhouse gas emissions from desalination

%30 increase in demand for water by 2030

1,500 m³/day potable water in 15 months

1 Increased energy efficiency
2 Reduced cost of desalination

Energy Inputs

Seawater

Osmosis

Increased energy efficiency
Reduced cost of desalination
RENEWABLE POWERED SEAWATER DESALINATION

Energy Inputs

Potential
% 40 reduction in energy intensity

$94 Million in potential annual savings

500 M³/day in 15 months

3 Decreased environmental impact
4 Diversification of energy supply

Drinking Water

Seawater Osmosis

1,500 potable water/15 months

% 40 reduction in energy intensity

% 40 reduction in UAE greenhouse gas emissions from desalination

% 30 increase in demand for water by 2030

Increased energy
Decreased environmental
impact

Reduced cost of desalination
Diversification of energy supply

Pioneering Next Generation Desalination
RENEWABLE ENERGY SEAWATER DESALINATION PROGRAMME

A key step to achieving water security and reducing energy consumption

The construction of the First Desalination Plant in the UAE.

DEWA
Dubai Water and Electricity Authority was established.

FEWA
Establishment of the Federal Electricity and Water Authority.

1960
The founding of the United Arab Emirates, a federation consisting of seven emirates.

1971
DEWA
Dubai Water and Electricity Authority was established.

1992
ADWEA
Abu Dhabi Water and Electricity Authority was established.

1998
The Ministry of Environment and Water was established.

1999

2006
The completion of the UAE Water Strategy.

Water Conservation Strategy was launched.
Construction began in Masdar city, The World’s First Low Carbon City.

Inaugural World Future Energy Summit held.

International Water Summit announced

Water Conservation Strategy was launched.

Masdar launched renewable powered desalination pilot aiming to test and develop advanced energy-efficient seawater desalination technologies suitable to be powered by renewable energy sources.

The completion of the construction and the inauguration of Masdar’s 4 pilot programmes in Ghantoot, Abu Dhabi.

The completion of Abu Dhabi’s Strategic Tunnel Enhancement Programme

The launch of M-station, the UAE’s Largest Power and Desalination Plant.

The establishment of M-station, the UAE’s Largest Power and Desalination Plant.

The launch of the UAE Water Strategy.

The UAE’s Regulation & Supervision Bureau (RSB), in collaboration with Abu Dhabi Distribution Company (ADDC) and Al Ain Distribution Company (AADC), announced a revision to water and electricity tariffs.

During the Abu Dhabi Ascent in May, Masdar partnered with four global industry leaders to start the construction of the desalination plant.

The launch of the Abu Dhabi Sustainability Week (ADSW).

The UAE Water and Electricity Authority (DEWA) was established.

The establishment of the Federal Electricity and Water Authority (FEWA).

The founding of the United Arab Emirates, a federation consisting of seven emirates.


Ministry of Environment and Water was established.

The construction of the First Desalination Plant in the UAE.
PROJECT COMPLETION SCHEDULE
### Phases

**Phase 1: Assessment**
- Assess the best desalination techniques
- Determine the elements of success in the pilot project
- Determine proper sites for the pilot projects
- Prepare work offer requests

**Phase 2: Partnerships**
- Analyse offers
- Discuss agreements
- Analyse commercial projects and select the best and low-priced techniques
- Sign contracts for four pilot projects in Abu Dhabi

**Phase 3: The Testing**
- Design and engineering
- Manufacture
- Shipment
- Installation
- Trial operation

**Phase 4: Wide range implementation (Commercial)**
- Work plan and financial models
- Funding channels for commercial projects

### Actions Taken

**Established Points**
- Determine work sites
- Request pricing and labour offers
- Sign cooperation agreements
- Overall design for experimental projects

### Time Line

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“Water is more important than oil for the United Arab Emirates. We have to come up with ways to meet future demand and preserve natural resources for coming generations”

His Highness Sheikh Mohamed Bin Zayed Al Nahyan
Crown Prince of Abu Dhabi and Deputy Supreme Commander of the United Arab Emirates Armed Forces.